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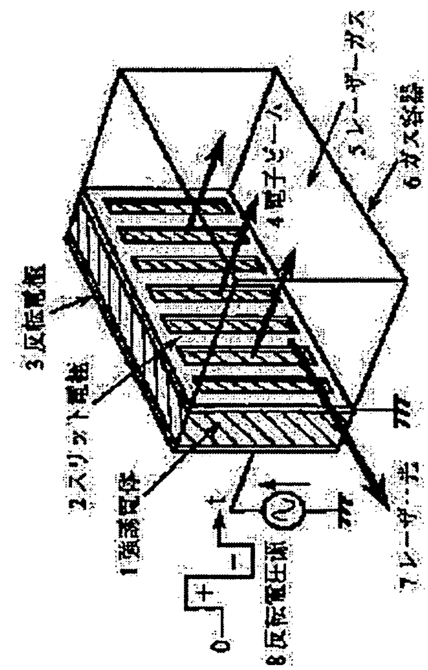
(54) GAS EXCITING APPARATUS

(57)Abstract:

PROBLEM TO BE SOLVED: To bombard electrons from a ferroelectric cathode directly into a gas by using an element formed of a ferroelectric substance or a combination of a ferroelectric substance with an electrode as a source for generating an electron beam, and applying a high-voltage pulse to the source.

SOLUTION: A plate-shaped ferroelectric body 1 is sandwiched between two electrodes 2 and 3 at both surfaces thereof. An electron emitting surface is grounded while covered with slit electrodes 2 so that part of the body 1 is exposed. On the other hand, the entire back surface of the substance 1 is completely covered with an inverting electrode 3. An inverting voltage source 8 is connected to the inverting electrode 3 on the back of the body 1, and a bipolar rectangular wave is applied to the electrode 3. According to this configuration, when the electrode 3 switches its polarity from positive to negative rapidly, the internal polarization of the substance 1 is inverted, thereby generating negatively polarized charges in the vicinity of the electrodes 2. As a result, electrons stored in the surface of the substrate 1 toward the electrodes 2 are repelled out electrostatically through the gap of each slit, and hence an electron beam 4 can be bombarded into a gas 5 directly.



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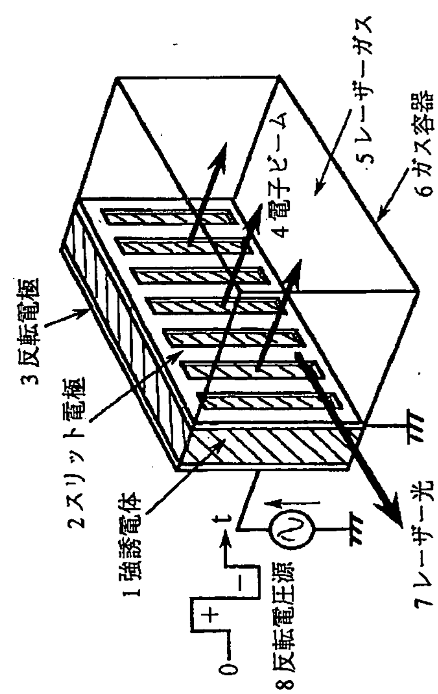
(54)【発明の名称】　ガス励起装置

(57)【要約】

【課題】本発明は、強誘電体陰極から電子をガス中に直接打ち込むことを可能にして、大出力・高効率・高繰り返し動作が可能なガス励起装置を提供することを目的としている。

【解決手段】本発明のガス励起装置は、電子ビーム発生源から放出させた電子をガス中に打ち込むことによってガスを励起するものである。電子ビーム発生源は、強誘電体にパルス電圧を印加することにより電子を放出させる。これによって、強誘電体陰極から電子をガス中に直接打ち込むことができる。



強誘電体からの放出電子によるガスの励起

【特許請求の範囲】

【請求項１】　電子ビーム発生源から放出させた電子をガス中に注入して励起するガス励起装置において、該電子ビーム発生源は、強誘電体にパルス電圧を印加することにより電子を放出させるものであることを特徴とするガス励起装置。

【請求項２】　前記電子ビーム発生源は、強誘電体板を２枚の電極板で挟み、この２枚の電極板にパルス電圧を印加したことを特徴とする請求項１に記載のガス励起装置。

【請求項３】　前記２枚の電極板の一方は、強誘電体の一部が外部に露出するように構成して該露出した面から電子を放出させるか、或いは、電子が透過する程度の十分に薄い金属蒸着膜または金属薄膜で構成して、その金属薄膜から電子を放出させることを特徴とする請求項２に記載のガス励起装置。

【請求項４】　前記２枚の電極板の裏面側の電極に、正極性電圧から負極性に反転する両極性方形波パルス電圧を印加し、かつ電子放出面側の電極板を接地したことを特徴とする請求項３に記載のガス励起装置。

【請求項５】　前記２枚の電極板の裏面側の電極に、正極性電圧から負極性に反転する両極性方形波パルス電圧を印加し、かつ電子放出面側の電極板を接地すると共に、加速電圧源を接続した陽極を設けたことを特徴とする請求項３に記載のガス励起装置。

【請求項６】　前記強誘電体とガスを接触させた状態で電子を強誘電体から引き出し、電子を強誘電体からガス中に直接注入することを特徴とする請求項１～５のいずれかに記載のガス励起装置。

【請求項７】　前記強誘電体から電子を一旦真空中に放出させ、その後、隔膜等を通して電子をガス中に注入することを特徴とする請求項１～３のいずれかに記載のガス励起装置。

【請求項８】　前記２枚の電極板の両方に、正極性電圧から負極性に反転する両極性方形波パルス電圧を印加し、かつ前記隔膜を接地して陽極として機能させたことを特徴とする請求項７に記載のガス励起装置。

【請求項９】　前記２枚の電極板間に、電子放出側の表面電極に対して裏面電極が正極性から負極性に反転する様な両極性方形波パルス電圧を印加するとともに、加速電圧源を表面電極に接続して両電極板を負高電位にし、かつ前記隔膜を接地して陽極として機能させたことを特徴とする請求項７に記載のガス励起装置。

【請求項１０】　前記放出させた電子ビームの軌道、断面形状、寸法を制御するための一対の電極を設け、該電極間に電圧を印加したことを特徴とする請求項１～８のいずれかに記載のガス励起装置。

【請求項１１】　前記放出させた電子ビームの軌道、断面形状、寸法を制御するための磁界発生コイルを備え、該コイルに電流を流したことを特徴とする請求項１～９のいずれかに記載のガス励起装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、例えばガスレーザー装置において用いられるガス励起装置に関する。ガスレーザー装置は、レーザー媒質ガスを励起しその周囲に光共振器等を設置することにより、ガス中の蓄積エネルギーをレーザー光に変換し取り出すものである。半導体産業等では、パルスあたりジュール程度の出力エネルギーの高繰り返しレーザー装置が既に広く使用されている。また将来の核融合用レーザードライバーとしてもガスレーザー装置は有力な候補である。この大出力レーザーの分野では未だ高繰り返し機能は備わっていないが、研究用の大口径ガスレーザー装置が既に開発され実験に使用されている。その他、ディスプレイ、化学反応装置、各種光源、オゾン源等、真空中あるいはガス中への電子放出源の性能向上にとって本発明は非常に有用である。

【０００２】

【従来の技術】従来の主要なガス励起方法は、電気エネルギーを直接ガスに注入するものである。陰極・陽極間の電界で電子を陰極から引き出し加速して高エネルギー電子ビームを生成し、その電子ビームをガス中に打ち込むことによってガスを励起していた。この方式に基づいて従来のガスレーザー装置には、大きく分けて「電子ビーム励起式」と「放電励起式」の２通りの方式があった。図６に従来技術の「電子ビーム励起式」の構成例を、図７に従来技術の「放電励起式」の構成例を示す。

【０００３】図６に示す従来の電子ビーム励起式装置においては、電子ビーム生成のための機構が大きく２段階に分けられる。第１に陰極表面からの電子放出と、第２に放出電子の加速である。電子放出においては、電子源となる陰極表面（電子放出面２０）に微小な突起を数多く設け、その無数の突起先端部で強電界を生じさせる。その結果、微小突起先端の強電界（数MV/cm以上）によって、突起先端部から電子を放出させる（電界放出）。

【０００４】次にその放出電子によって陰極表面（電子放出面２０）にプラズマを作り、表面全体をプラズマで覆う。このプラズマが実質的に電子放出用の陰極の役割をする。対向陽極と表面プラズマとの間の電界によって陰極表面プラズマからは容易に電子が引き出される。図６においてはガス保持薄膜１０が接地されており、この薄膜が陽極の働きをする。すなわち真空中（真空加速部９）の陰極２１とガス保持薄膜１０との間で電子は加速され、高エネルギーの電子ビーム４が生成される。生成された電子ビームは、ガス保持薄膜１０を通して大気圧程度のレーザーガス５に打ち込まれる。その結果レーザーガス分子は電子の衝突によって励起される。

【０００５】図６に代表される電子ビーム励起式装置において、典型的な陰極面積（電子放出面２０）は長さ100cm、幅10cm程度である。陰極２１には加速電圧源１１

を接続し、負高電圧パルス（-数100～-1000kV，パルス幅：数10～数100ns）を印加する。陽極（ガス保持薄膜１０）には通常金属薄膜を用い、真空部と大気圧程度のレーザーガスを隔てている。陽極薄膜の寸法は、通常、厚み数10ミクロン、長さ100cm、幅30cm程度である。実際には、この真空とガスとの境界に設置する隔膜を、陽極用の金属薄膜とガス圧力保持用の薄膜の２枚に分け、両者を数cm程度の間隔で平行に向かい合わせて置き、ともに接地して用いる場合が多い。この場合、電子ビームは真空中から２枚の金属薄膜を透過してガス中に打ち込まれることになる。励起するガスの容積は大型装置では口径１m、長さ２mに達する。

【０００６】一方、図７に示す従来技術の放電励起式装置では放電管内にレーザーガスを充填し、電極間の放電によってガスを励起するものである。図７において、ガス容器６の両側に陰極２１と陽極１２を設置し、両者の間にレーザーガス５を満たす。電極の幅及び間隔は共に数cm程度、電極の長さは50～100cm程度である。加速電圧源１１を陰極２１に接続することにより電極間に高電圧（数10kV）を印加し、電極間のグロー放電によって媒質ガスを励起する。安定なグロー放電を得るためには、放電開始時に十分な量の電荷を放電領域に一様に生成しておく必要があり、そのためにX線照射または紫外線照射によりレーザーガス５の予備電離を行う。

【０００７】

【発明が解決しようとする課題】従来の電子ビーム励起式のガスレーザー装置では、真空とレーザー媒質ガスを隔てる薄膜（図６のガス保持薄膜１０）において電子の蓄積・散乱損失が大きく、このエネルギー損失が装置全体の効率を大きく制限していた。同時にレーザー装置の長時間動作においては、ガスと真空を隔てる薄膜シール部分での真空漏れ、薄膜の機械的強度低下、レーザーガスによる薄膜の腐食、それに伴うレーザーガスの汚染という問題があった。一般に電子ビーム励起式の装置は大口径化が容易なため、大出力レーザー光の発生に適している。しかしガス保持薄膜１０を使用していたために、長時間にわたる高繰り返し動作の下で大出力レーザー光を高効率で連続的に生成することが不可能であった。

【０００８】また従来の電子ビーム励起式装置においては、電子ビームの生成が前述の電子放出機構によって大きく制約されていた。すなわち陰極表面からの電子放出量が微小突起の形状・大きさ、数密度に依存するため、これらの幾何学的条件が不十分な場合には、放出電子による陰極表面プラズマの生成に時間を要していた。そのため電子ビーム電流波形の立ち上がり時間の短縮が困難であった（40～50ns程度）。また電子ビーム発生部のインピーダンスが電極面積・間隔、印加電圧に依存するので、電子ビーム電流量がこれらの条件で規定され、電子ビーム放出面積の自由な拡大が困難であった。さらに陰極表面プラズマが時間とともに陽極方向へ進展するので実質的な電極間隔が時間と共に減少し、インピーダンスの時間的減少をもたらしていた。このため電圧印加時間内において電子ビーム加速電圧及び電流値を一定に保つことが難しかった。

【０００９】放電励起式の装置においても電極からの電子放出に困難があった。この方式のガスレーザー装置では、陰極からの電子放出のためにガスが充填された電極間に高電界を印加する必要があり、そのためにガス中でのグロー放電が不安定になりアーク放電に移行しやすいという欠点があった。放電励起式の装置は高繰り返し動作には優れているが、これらの放電不安定性のために放電管の大口径化、すなわち大面積・大出力レーザー光の生成が不可能であった。

【００１０】そこで、本発明は、かかる問題点を解決して、強誘電体陰極から電子をガス中に直接打ち込むことを可能にして、大出力・高効率・高繰り返し動作が可能なガス励起装置を提供することを目的としている。

【００１１】

【課題を解決するための手段】本発明は、強誘電体または強誘電体と電極で構成した素子を電子ビーム発生源として用いる。ただし電子ビーム発生源における強誘電体の寸法、形状、及び電極の構成方法は１つに限定されない。また強誘電体から隔てられた場所に強誘電体からの電子引き出しのための機構を必ずしも必要としない。

【００１２】強誘電体を用いた電子放出源の一つの作成方法として、強誘電体板を２枚の電極板で挟むことにより電子放出素子を構成する（図１～図５）。強誘電体板の電子放出面は、強誘電体の一部が外部に露出する様にスリット状等の表面形状の電極で覆うか、或いは、電子が透過する程度の十分に薄い金属蒸着膜又は金属薄膜等で覆い、接地する（図１～図５のスリット電極２）。裏面側は強誘電体の全面を一様な電極で完全に覆い（図１～図５の反転電極３）、後述の高電圧パルスを印加するための電源を接続する（反転電圧源８）。

【００１３】始めに裏面側の反転電極３に正極性パルスを印加し、表面側のスリット状電極または金属薄膜等（スリット電極２）に電子を蓄積する。スリット状電極の場合はスリットの隙間の強誘電体表面にも電子が蓄積する。次に反転電極３の電圧極性を急速に負に反転し、誘電体内の分極を反転する。この急速な分極反転により、スリット状電極の場合は、スリットの隙間の強誘電体表面に蓄積していた電子が、スリットの隙間を通して静電的に外部に弾き出される。また金属蒸着膜または金属薄膜等で構成した電極の場合は、薄膜に蓄積した電子が、薄膜表面から直接或いは薄膜を通過して静電的に外部に弾き出される。弾き出された電子をそのままガス中に打ち込み、ガス分子に衝突させてガスを励起する。

【００１４】この電子弾き出しの際に、条件が許せば初めから反転電極３に負極性パルスのみを印加し、途中で電圧を反転せずに同様の効果を生じさせてもよい。必要

に応じて、強誘電体から放出した電子を外部電界で加速してもよい（図２、３）。また、放出電子ビームの軌道、断面形状、或いは寸法を任意の場所で制御してもよい（図４、５）。

【００１５】このようにして、強誘電体とガスを接触させた状態で、電子を強誘電体からガス中に直接放出させることが可能になる。この結果、以下の事項または動作が可能となる。

【００１６】（１）ガス中への直接電子放出が可能となるので、電子ビーム励起式ガスレーザー装置において使用していたガス保持薄膜１０を取り去り、電子ビームを真空を介さずに直接ガス中に打ち込むガス励起方式が可能になる。この方式を採用することにより、これまでガス保持薄膜に起因していた様々な問題が解消する。

（２）電子ビーム励起式装置において、陰極から真空中への電子放出の際に陰極表面プラズマの生成が不要になる。したがって従来の装置において、電子ビーム電流の立ち上がり時間を大幅に短縮できる。

（３）電子ビーム励起式装置において、陰極表面から陽極方向へのプラズマの進展という問題が解消する。従って従来の装置において、電子ビームの加速電圧及び電流値の時間的変動が低減する。

（４）電子ビーム励起式および放電励起式装置において、電子ビーム生成のための既存の規定条件（電極面積、電極間隔、電界強度等）が大幅に緩和されるので、放出電子ビーム断面積の拡大が非常に容易になる。

（５）放電励起式装置において、電子放出のための強電界が不要になるので電極間の電圧を低減でき、グロー放電の安定性が向上する。

（６）放電励起式装置において電子放出が非常に容易になり、従来の装置で必須であったガスの予備電離が不要となる。

【００１７】

【発明の実施の形態】以下、本発明を、図１～図５に示すような強誘電体で構成した素子から電子を放出させ、電子ビームを生成してガス中に打ち込みガスを励起するガスレーザー装置を例にして詳細に説明する。

【００１８】図１は、強誘電体とガスを接触させ、強誘電体から電子を直接ガス中に放出させてガスを励起する第１の構成例を示している。ここでは板状の強誘電体１の両面を２枚の電極で挟む構成例を示す。強誘電体の厚みは数100ミクロンから１mm程度あれば使用可能であるが、目的、使用方法に応じてそれ以上の厚みでもよい。電子放出面では強誘電体の一部が露出するようにスリット状の電極（スリット電極２）で覆い接地する。スリットの幅（強誘電体露出面の幅）は強誘電体１の厚みと同程度か或いはそれ以下にすることが望ましい。ただしスリットの幅がゼロでは電子は放出しない。スリット電極の厚みは強誘電体の厚みに比べて十分に薄い方が電子放出に有利なので、スリット電極は金属蒸着或いは十分に薄い金属メッシュ等によって構成してもよい。またはスリット電極等を使用せず、電子の透過が可能な程度の薄さの金属蒸着膜又は金属薄膜で電子放出面全体を覆ってもよい。一方その反対側の裏面においては、強誘電体全面を完全に電極で覆う（反転電極３）。

【００１９】反転電圧源８を裏面の反転電極３に接続し、反転電極に図示の様な両極性の方形波を印加する。印加電圧の大きさは強誘電体の絶縁破壊強度で決まるが、強誘電体の厚み１mmあたり約数kV程度である。パルス幅は使用目的によるが、正極性、負極性ともに数10ns程度或いはそれ以上である。

【００２０】初めに反転電極３に正極性電圧を印加したとき、通常のコンデンサーの充電と同様に強誘電体１の両面に電荷が蓄積する。電子放出面となるスリット電極２側では、スリットの隙間の部分の強誘電体表面にも電子が蓄積する。

【００２１】次に反転電極３の極性が正から負に急速に反転すると強誘電体１内部の分極が反転し、スリット電極２側附近の強誘電体内部では負の分極電荷が発生する。その結果スリット電極側の強誘電体表面に蓄積していた電子が、スリットの隙間を通して静電的に外部に弾き出される。電子放出面側の電極が金属蒸着膜または金属薄膜等によって構成される場合は、それらの薄膜表面から直接或いは薄膜を通して電子が弾き出される。電子が弾き出される時間はおよそ負極性パルス幅に等しい。弾き出された電子を直接レーザーガス５中に打ち込み、ガス分子に衝突させることによりレーザーガスを励起する。この結果、図示の方向にレーザー光７を取り出すことができる。

【００２２】この例に従うことによって、従来の電子ビーム励起式装置において使用していたガス保持薄膜が不要となり、電子ビームを真空を介さずに直接ガス中に打ち込むことが可能になる。この方式を採用することにより、ガス保持薄膜に起因した様々な問題点が解消され、装置のエネルギー転送効率も大幅に改善する。また従来の放電励起式装置においても電子放出が非常に容易になり、放電の安定性が得られ、装置の大口径化・大出力化が可能となる。

【００２３】図２は、強誘電体から電子を一旦真空中に放出させ、次に薄膜を通してガス中に打ち込む第２の構成例を示している。強誘電体からの電子放出機構は、図１に例示した場合と全く同じである。すなわち裏面の反転電極３に反転電圧源８を接続し、図示の様な両極性パルスを反転電極３に印加し、表面のスリッド電極２から電子を静電的に弾き出す。

【００２４】この第２の構成例では、強誘電体１の両側のスリット電極２、反転電極３の双方に加速電圧源１１を接続し、負高電圧（～数100kV）を印加する。従って接地されたガス保持薄膜１０（金属薄膜）が陽極として機能する。強誘電体表面のスリット電極側から放出した

電子は、真空加速部９で加速され高エネルギーの電子ビーム４となり、ガス保持薄膜１０を通してレーザーガス５中に打ち込まれる。ガス保持薄膜は通常、数10ミクロンの厚みなので、電子ビームは薄膜を透過しレーザーガス中に入る。高エネルギーの電子ビームが必要な場合は、この例の様に電子を一旦真空中に放出させて加速し、その後薄膜を通してガス中に打ち込むと有利な場合が多い。

【００２５】本発明は、従来の電子ビーム励起式装置における電子ビーム発生部の特性改善に大きく寄与する。従来の装置においては、電子ビーム電流波形の立ち上がりの遅さ、電子ビーム継続時間内（数10ns～数100ns程度）での電圧、電流値の変動、電子ビーム断面積拡大の困難さ、等の不都合があった。これらは全て陰極からの電子放出の難しさに起因していた。すなわち電子ビーム励起式装置においては、真空中に設置した陰極表面（図６の電子放出面２０）に数多くの微小突起（高さ、幅、数10～数100ミクロン）を設けて突起先端部で電界を強調し（数MV/cm以上）、その局所的高電界部から電子を真空中に放出させていた（電界放出）。従って電子放出量が陰極表面の微小突起の形、大きさ、突起数の面積密度、等に依存するため、それら陰極表面の幾何学的条件が不十分な場合は良好な電子放出特性が得られなかった。また微小突起からの電子放出後プラズマが陰極表面を覆う際に待ち時間が生じ、これが電子ビーム波形の立ち上がり時間の短縮を困難にしていた（40～50ns程度）。さらに陰極表面プラズマの陽極方向への進展に伴って、電子ビーム発生部（陰極・陽極間）のインピーダンスが時間的に減少し、その結果電子ビーム電圧・電流がパルス後半で低下する傾向にあった。電極面積拡大の困難さもこれらの制約によるものであった。

【００２６】図２に示した第２の構成例においては、電子放出に際して陰極表面に強電界を生じさせる必要がなくなり、真空中への電子放出が非常に容易になる。また陰極表面プラズマの生成も不要となるので、従来装置における電子ビーム生成に関しての様々な制約が大幅に軽減される。すなわち電子ビーム励起式装置において従来通りガス保持薄膜を使用する場合においても、これまで困難であった電子ビーム電流波形の立ち上がり時間の短縮、電子ビーム電圧、電流値の安定化、電極面積の拡大、等が容易になり、装置の特性を大幅に改善することが可能になる。この第２の構成例に従うことによって、更に大口径・大出力の高性能電子ビーム励起式装置の設計が可能になる。

【００２７】図３は、電子を直接ガス中に放出させ、ガス中で電子を加速する第３の構成例を示している。強誘電体からの電子放出機構は、第１及び第２の構成例の場合と全く同じである。図３に示すように強誘電体１で構成した電子放出源を陽極１２と対向させて設置し、両者の間をレーザーガス５で満たす。陽極１２には加速電圧源１１を接続して数10kVの正電圧を印加し、強誘電体１から放出した電子をレーザーガス５中で加速するとともにレーザーガス５を励起する。レーザー光７は図示の方向に取り出す。

【００２８】この第３の構成例は、従来の放電励起式ガスレーザー装置を改良したことに相当する。この構成例において有利な点は、電子放出のために陰極表面に強電界を生じさせる必要が無くなることである。このため放電励起式装置において電極間電圧を低減でき、グロー放電の安定性が格段に向上する。また電子放出が容易になることにより、これまで放電励起式装置で必須であったガスの予備電離機構を取り除くことができ、装置の大幅な簡略化が可能となる。これらの結果、電極面積及び電極間隔も比較的自由に設定することが可能になり、これまで不可能であった放電安定性に優れた大口径・大出力放電励起式ガスレーザー装置が実現する。

【００２９】図４は、第１の構成例において、電子ビームを電界によって制御する第４の構成例を示す。図４においては、ガス容器６の上と下の面に電界発生電極１３を設置し、電界発生電圧源１４によって高電圧を印加して鉛直方向に電界１５を生じさせる。この電界１５によって電子ビーム４の軌道、断面形状、寸法を制御する。電界発生電極１３の数は２つに限定されない。電界１５の方向も鉛直方向に限定されない。また後述の磁界による電子ビーム制御（図５）と併用してもよい。この電子ビーム制御方法は、第１の構成例のみでなく他の構成例に適用してもよい。

【００３０】図５は、第１の構成例において、電子ビームを磁界によって制御する第５の構成例を示す。図５においては、ガス容器６の周囲に電子ビーム４を囲む様に磁界発生コイル１８を設置し、励磁電流源１７によって大電流を流して電子ビーム４と平行に磁界１６を生じさせる。この磁界１６によって電子ビーム４の軌道、断面形状、寸法を制御する。磁界発生コイル１８は２つに限定されない。磁界１６の方向も電子ビーム４の方向に限定されない。また前述の電界による電子ビーム制御（図４）と併用してもよい。この電子ビーム制御方法は、第１の構成例のみでなく他の構成例に適用してもよい。

【００３１】

【発明の効果】本発明を電子ビーム励起式ガスレーザー装置に適用すると、同種装置においてこれまで不可欠であったガス保持薄膜を取り除くことが可能となり、全く新しいガス励起方式の大口径ガスレーザー装置が実現する。この新方式の装置では、薄膜における電子の蓄積・散乱損失、薄膜の破損、真空漏れ、薄膜の腐食、ガスの汚染、等の問題が一挙に解消する。この結果、大出力ガスレーザー装置の長時間に渡る高効率・高繰り返し動作が可能となる。

【００３２】本発明を、ガス保持薄膜を使用する従来通りの電子ビーム励起式装置に適用する場合においても、

電子ビーム電流の立ち上がり時間の短縮、電子ビーム電圧、電流の安定性の向上が可能となり、また電極面積の拡大も非常に容易となる。これらの結果、電子ビーム励起式装置の一層の高性能化、大口径化・大出力化が可能になる。

【００３３】本発明を放電励起式ガスレーザー装置に適用すると、電子放出の際に必要だった陰極表面の強電界が不要となり電極間電界の低減が可能となるので、グロー放電の安定性が格段に向上する。また電極面積・間隔の拡大が非常に容易になるのでガス容積の大幅な増大が可能となる。さらにガスの予備電離機構も不要となるので、装置の大幅な簡略化も可能となる。これらの結果、これまで困難であった放電励起式ガスレーザー装置の大口径化、大出力化が実現する。

【００３４】以上、従来の電子ビーム励起式、放電励起式、双方の短所を補い長所を合わせた、大出力、高効率、高繰り返し動作が可能な全く新しい高性能ガスレーザー装置が実現する。本発明は、高繰り返し動作が要求される将来の核融合用大出力・高効率ガスレーザードライバーの実現、或いは産業界で既に広く使用されている高繰り返しレーザー装置の大出力化、大口径化に大きく貢献する。

【図面の簡単な説明】

【図１】本発明の第１の構成例を示し、強誘電体からガス中へ電子を直接放出させてガスを励起する例を示す。

【図２】本発明の第２の構成例を示し、強誘電体から電子を一旦真空中に放出させて加速し、その後薄膜を通過させてガス中に打ち込む例を示す。

【図３】本発明の第３の構成例を示し、強誘電体からガス中に直接放出させた電子をガス中で加速する例を示す。

【図４】本発明の第４の構成例を示し、第１の構成例において電子ビームの軌道、断面形状、寸法を電界で制御する例を示す。

【図５】本発明の第５の構成例を示し、第１の構成例において電子ビームの軌道、断面形状、寸法を磁界で制御する例を示す。

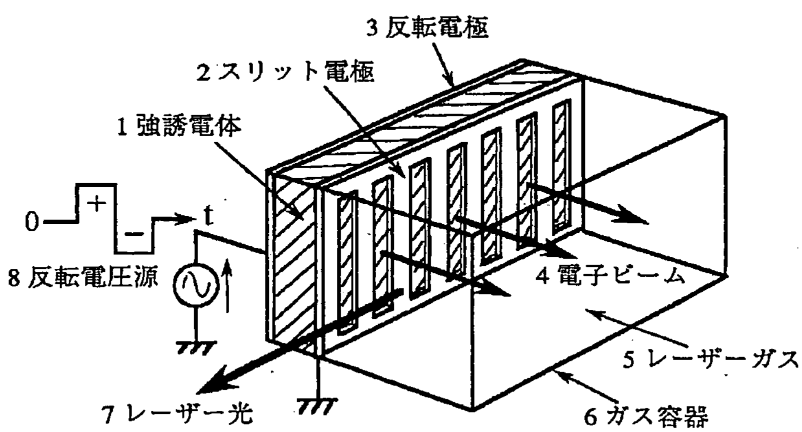
【図６】従来の電子ビーム励起式ガスレーザー装置を示す。

【図７】従来の放電励起式ガスレーザー装置を示す。

【符号の説明】

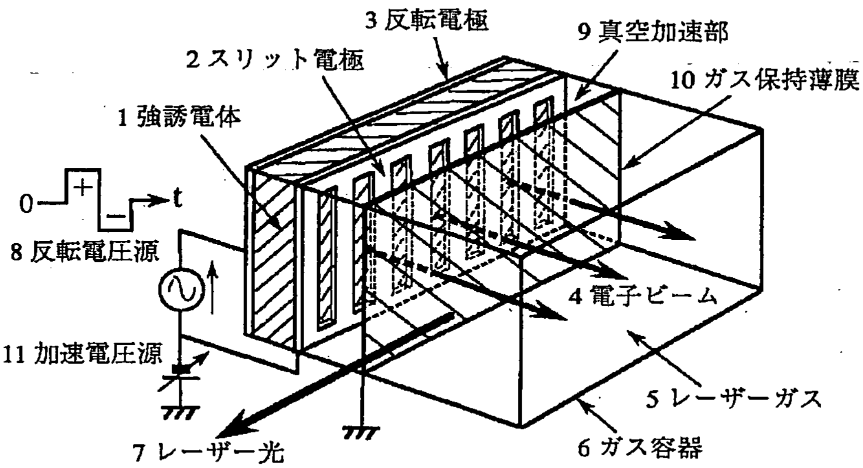
1　強誘電体
2　スリット電極
3　反転電極
4　電子ビーム
5　レーザーガス
6　ガス容器
7　レーザー光
8　反転電圧源
9　真空加速部
１０　ガス保持薄膜
１１　加速電圧源
１２　陽極
１３　電界発生電極
１４　電界発生電圧源
１５　電界
１６　磁界
１７　励磁電流源
１８　磁界発生コイル
１９　絶縁板
２０　電子放出面
２１　陰極

【図１】



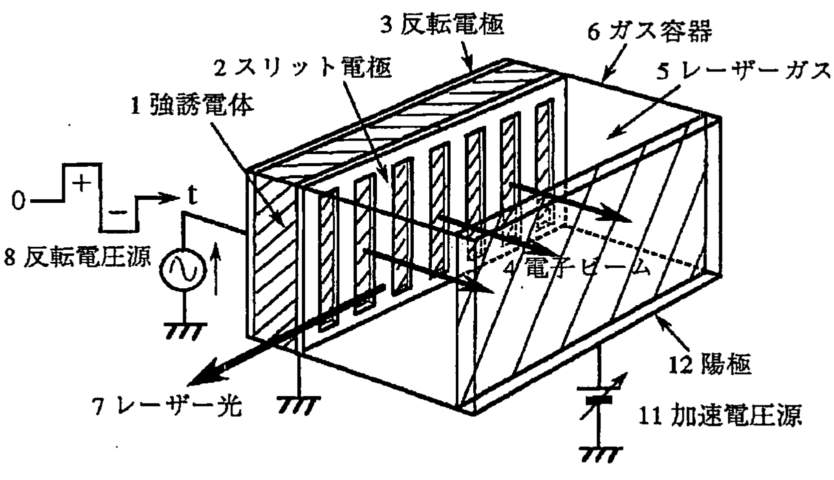
強誘電体からの放出電子によるガスの励起

【図２】



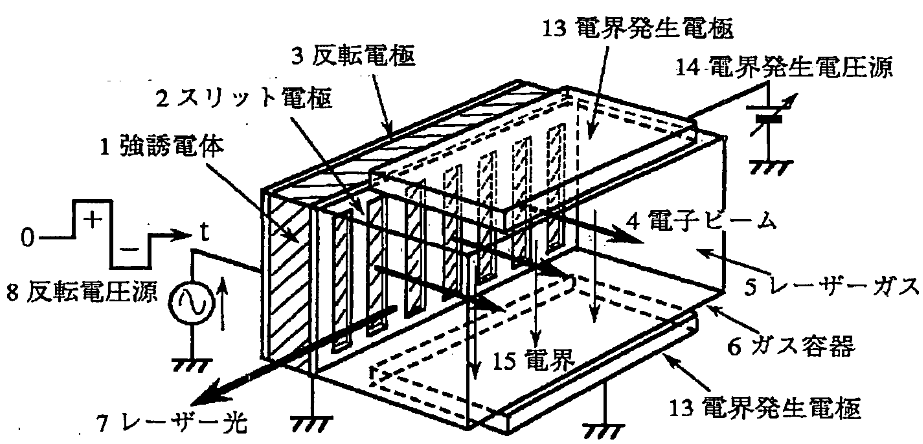
真空中での放出電子の加速

【図３】



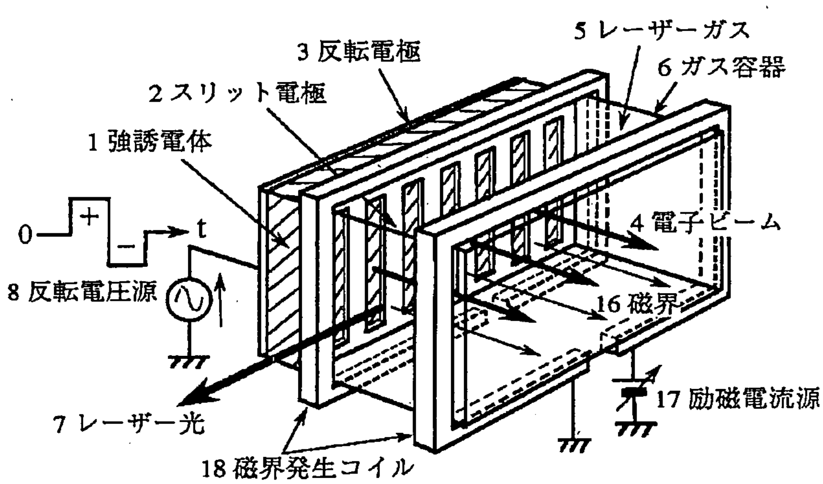
ガス中での放出電子の加速

【図４】



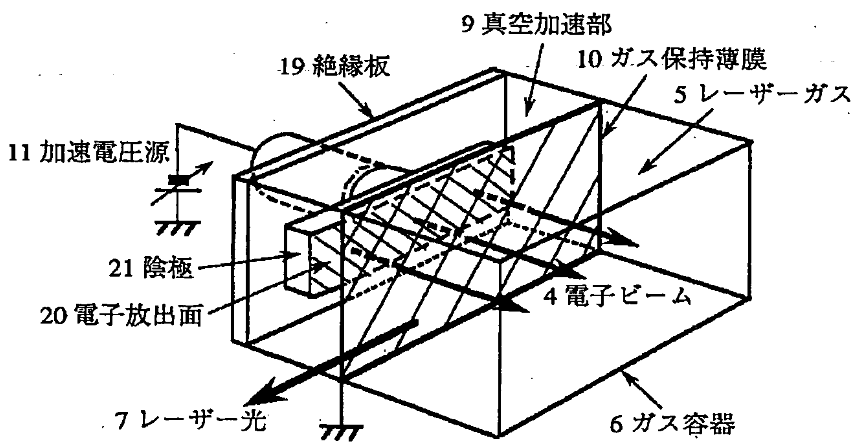
電界による電子ビーム制御

【図５】



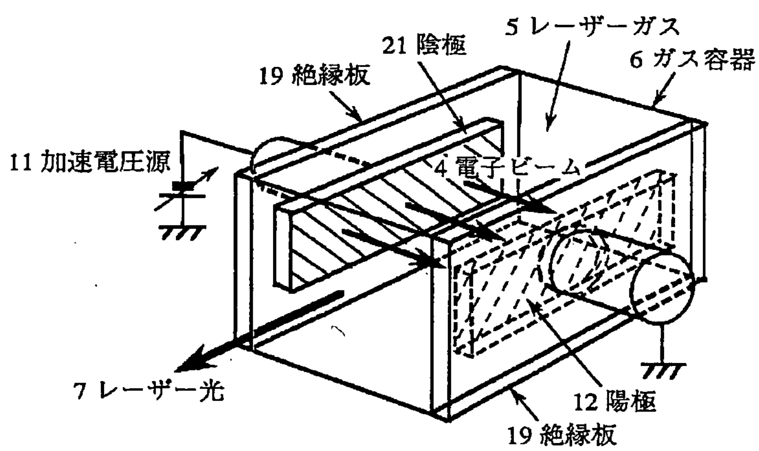
磁界による電子ビーム制御

【図６】



従来技術（電子ビーム励起式ガスレーザー装置）

【図７】



従来技術（放電励起式ガスレーザー装置）

【手続補正書】
【提出日】平成１１年7月１９日（１９９９．７．１９）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】特許請求の範囲
【補正方法】変更
【補正内容】
【特許請求の範囲】
【請求項１】　電子ビーム発生源から放出させた電子をガス中に注入して励起するガス励起装置において、該電子ビーム発生源は、強誘電体にパルス電圧を印加することにより電子を放出させるものであることを特徴とするガス励起装置。
【請求項２】　前記電子ビーム発生源は、強誘電体板を２枚の電極板で挟み、この２枚の電極板にパルス電圧を印加したことを特徴とする請求項１に記載のガス励起装置。
【請求項３】　前記２枚の電極板の一方は、強誘電体の一部が外部に露出するように構成して該露出した面から電子を放出させるか、或いは、電子が透過する程度の十分に薄い金属蒸着膜または金属薄膜で構成して、その金属薄膜から電子を放出させることを特徴とする請求項２

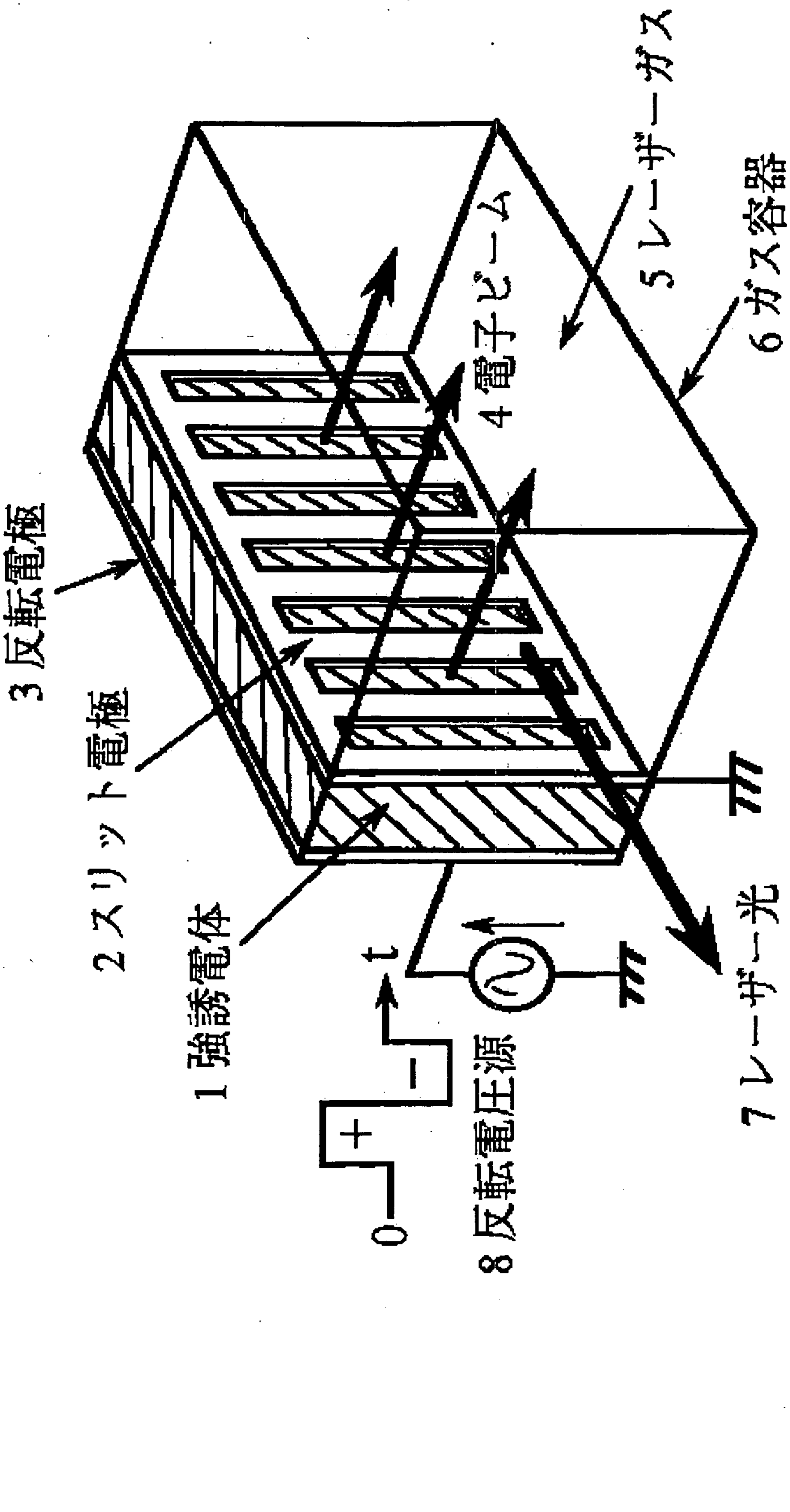
に記載のガス励起装置。
【請求項４】　前記２枚の電極板の裏面側の電極に、正極性から負極性に反転する両極性方形波パルス電圧を印加し、かつ電子放出面側の電極板を接地したことを特徴とする請求項３に記載のガス励起装置。
【請求項５】　前記２枚の電極板の裏面側の電極に、正極性から負極性に反転する両極性方形波パルス電圧を印加し、かつ電子放出面側の電極板を接地すると共に、加速電圧源を接続した陽極を設けたことを特徴とする請求項３に記載のガス励起装置。
【請求項６】　前記強誘電体とガスを接触させた状態で電子を強誘電体から引き出し、電子を強誘電体からガス中に直接注入することを特徴とする請求項１～５のいずれかに記載のガス励起装置。
【請求項７】　前記強誘電体から電子を一旦真空中に放出させ、その後、隔膜等を通して電子をガス中に注入することを特徴とする請求項１～３のいずれかに記載のガス励起装置。
【請求項８】　前記２枚の電極板間に、電子放出側の表面電極に対して裏面電極が正極性から負極性に反転する様な両極性方形波パルス電圧を印加するとともに、加速電圧源を表面電極に接続して両電極板を負高電位にし、かつ前記隔膜を接地して陽極として機能させたことを特徴とする請求項７に記載のガス励起装置。
【請求項９】　前記放出させた電子ビームの軌道、断面形状、寸法を電界で制御するための一対の電極を設け、該電極間に電圧を印加したことを特徴とする請求項１～８のいずれかに記載のガス励起装置。
【請求項１０】　前記放出させた電子ビームの軌道、断面形状、寸法を磁界で制御するための磁界発生コイルを備え、該コイルに電流を流したことを特徴とする請求項１～９のいずれかに記載のガス励起装置。

【手続補正書】
【提出日】平成１２年1月３１日（２０００．１．３１）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】特許請求の範囲
【補正方法】変更
【補正内容】
【特許請求の範囲】
【請求項１】　電子ビーム発生源から放出させた電子をレーザーガス中に注入して励起するガス励起装置において、該電子ビーム発生源は、強誘電体にパルス電圧を印加することにより電子を放出させるものであることを特徴とするガス励起装置。
【請求項２】　前記電子ビーム発生源は、強誘電体板を２枚の電極板で挟み、この２枚の電極板にパルス電圧を印加したことを特徴とする請求項１に記載のガス励起装置。
【請求項３】　前記２枚の電極板の一方は、強誘電体の一部が外部に露出するように構成して該露出した面から電子を放出させるか、或いは、電子が透過する程度の十分に薄い金属蒸着膜または金属薄膜で構成して、その金属薄膜から電子を放出させることを特徴とする請求項２に記載のガス励起装置。
【請求項４】　前記２枚の電極板の裏面側の電極に、正極性から負極性に反転する両極性方形波パルス電圧を印加し、かつ電子放出面側の電極板を接地したことを特徴とする請求項３に記載のガス励起装置。
【請求項５】　前記２枚の電極板の裏面側の電極に、正極性から負極性に反転する両極性方形波パルス電圧を印加し、かつ電子放出面側の電極板を接地すると共に、加速電圧源を接続した陽極を設けたことを特徴とする請求項３に記載のガス励起装置。
【請求項６】　前記強誘電体とガスを接触させた状態で電子を強誘電体から引き出し、電子を強誘電体からガス中に直接注入することを特徴とする請求項１～５のいずれかに記載のガス励起装置。
【請求項７】　前記強誘電体から電子を一旦真空中に放出させ、その後、ガス保持薄膜を通して電子をガス中に注入することを特徴とする請求項１～３のいずれかに記載のガス励起装置。
【請求項８】　前記２枚の電極板間に、電子放出側の表面電極に対して裏面電極が正極性から負極性に反転する様な両極性方形波パルス電圧を印加するとともに、加速電圧源を表面電極に接続して両電極板を負高電位にし、かつ前記ガス保持薄膜を接地して陽極として機能させたことを特徴とする請求項７に記載のガス励起装置。
【請求項９】　前記放出させた電子ビームの軌道、断面形状、寸法を電界で制御するための一対の電極を設け、該電極間に電圧を印加したことを特徴とする請求項１～８のいずれかに記載のガス励起装置。
【請求項１０】　前記放出させた電子ビームの軌道、断面形状、寸法を磁界で制御するための磁界発生コイルを備え、該コイルに電流を流したことを特徴とする請求項１～９のいずれかに記載のガス励起装置。

CLAIMS

[Claim(s)]
[Claim 1] When this electron beam generation source impresses a pulse voltage to a ferroelectric in the gas excitation equipment which pours in into gas the electron made to emit from an electron beam generation source, and excites it, it is gas excitation equipment characterized by being the thing to which an electron is made to emit.
[Claim 2] Said electron beam generation source is gas excitation equipment according to claim 1 characterized by having inserted the ferroelectric plate with two electrode plates, and impressing a pulse voltage to these two electrode plates.
[Claim 3] One side of said two electrode plates is gas excitation equipment according to claim 2 characterize by constitute from the metal vacuum evaporationo film thin enough or metal thin film which constitutes , and is make to emit an electron from the this exposed field , or an electron penetrates , and which is extent so that some ferroelectrics may be outside exposed , and make an electron emit from the metal thin film .
[Claim 4] Gas excitation equipment according to claim 3 characterized by having impressed the amphipathy square wave pulse voltage reversed from a straight polarity electrical potential difference to negative polarity to the electrode by the side of the rear face of said two electrode plates, and grounding the electrode plate by the side of an electron emission side.
[Claim 5] Gas excitation equipment according to claim 3 characterized by preparing the anode plate which connected the source of acceleration voltage to it while impressing the amphipathy square wave pulse voltage reversed from a straight polarity electrical potential difference to negative polarity to the electrode by the side of the rear face of said two electrode plates and grounding the electrode plate by the side of an electron emission side to it.
[Claim 6] Gas excitation equipment according to claim 1 to 5 characterized by pulling out an electron from a ferroelectric where said ferroelectric and gas are contacted, and pouring in an electron directly into gas from a ferroelectric.
[Claim 7] Gas excitation equipment according to claim 1 to 3 characterized by making an electron once emit into a vacuum from said ferroelectric, and pouring in an electron into gas through a diaphragm etc. after that.
[Claim 8] Gas excitation equipment according to claim 7 characterized by having impressed the amphipathy square wave pulse voltage reversed from a straight polarity electrical potential difference to negative polarity to said both two electrode plates, and having grounded said diaphragm to it, and making it function on it as an anode plate.
[Claim 9] Gas excitation equipment according to claim 7 which connects the source of acceleration voltage to a surface electrode, and makes a two-electrodes plate negative quantity potential, and is characterized by having grounded said diaphragm and making it function as an anode plate while impressing an amphipathy square wave pulse voltage which a rear-face electrode reverses from straight polarity to the surface electrode by the side of electron emission between said two electrode plates at negative polarity.
[Claim 10] Gas excitation equipment according to claim 1 to 8 characterized by having prepared the electrode of the pair for controlling the orbit of said electron beam made to emit, a cross-section configuration, and a dimension, and impressing an electrical potential difference to this inter-electrode ones.
[Claim 11] Gas excitation equipment according to claim 1 to 9 characterized by having had the field generating coil for controlling the orbit of said electron beam made to emit, a cross-section configuration, and a dimension, and passing a current in this coil.

[Translation done.]



強誘電体からの放出電子によるガスの励起

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the gas excitation equipment used for example, in gas laser equipment. By exciting laser medium gas and installing an optical resonator etc. in the perimeter, gas laser equipment changes the stored energy in gas into laser light, and takes it out. In semiconductor industry, the high repeat laser equipment of the output energy of joule extent is already widely used per pulse. Moreover, he is a candidate with strong gas laser equipment also as a future laser driver for nuclear fusion. In the field of this high power laser, although the high repeat function is not equipped, the diameter gas laser equipment of macrostomia for research is already developed, and it is still used for the experiment. In addition, this invention is very useful for the improvement in the engine performance of sources of electron emission to the inside of a vacuum or gas, such as a display, chemical reaction equipment, the various light sources, and a source of ozone.
[0002]
[Description of the Prior Art] The main conventional gas excitation approaches pour electrical energy into direct gas. By the electric field between cathode and an anode plate, the electron was pulled out from cathode, it accelerated, the high energy electron beam was generated, and gas was excited by driving in the electron beam into gas. Based on this method, it roughly divided into conventional gas laser equipment, and there were two kinds of methods, an "electron-beam-excitation type" and a "discharge excitation type", in it. The example of a configuration of the "electron-beam-excitation type" of the conventional technique is shown in drawing 6 , and the example of a configuration of the "discharge excitation type" of the conventional technique is shown in drawing 7 .
[0003] In the conventional electron-beam-excitation type equipment shown in drawing 6 , the device for electron beam generation is roughly divided into two steps. They are the electron emission from the 1st cathode surface, and acceleration of the 2nd emission electron. In electron emission, many minute projections are prepared in the cathode surface (electron emission side 20) used as an electron source, and a heavy current community is produced in the countless projection point. Consequently, an electron is made to emit from a projection point by the heavy current community (several more than MV/cm) at the tip of a minute projection (field emission).
[0004] Next, by the emission electron, the plasma is made to a cathode surface (electron emission side 20), and the whole front face is covered with the plasma. This plasma carries out the role of the cathode for electron emission substantially. From the cathode surface plasma, an electron is easily pulled out by the electric field between an opposite anode plate and the surface plasma. The gas maintenance thin film 10 is grounded in drawing 6 R> 6, and this thin film commits an anode plate. That is, an electron is accelerated between the cathode 21 in a vacuum (vacuum acceleration section 9), and the gas maintenance thin film 10, and the electron beam 4 of high energy is generated. The generated electron beam is driven into the laser gas 5 of atmospheric pressure extent through the gas maintenance thin film 10. As a result, a laser gas molecule is excited by electronic collision.
[0005] In the electron-beam-excitation type equipment represented by drawing 6 , a typical cathode area (electron emission side 20) is about 10cm in die length of 100cm, and width of face. The source 11 of acceleration voltage is connected to cathode 21, and a negative high-voltage pulse (-several 100- -1000kV, pulse width : a-ten number - 100ns of numbers) is impressed. In the anode plate (gas maintenance thin film 10), the laser gas of the vacuum section and atmospheric pressure extent is usually separated using the metal thin film. The dimension of an anode plate thin film is usually about 30cm in the thickness number of 10 microns, die length of 100cm, and width of face. The diaphragm installed in the boundary of this vacuum and gas is divided into two sheets, the metal thin film for anode plates, and the thin film for gas pressure maintenance, in fact, both are opposed in parallel at intervals of about several cm, and it places, and it both grounds and uses in many cases. In this case, an electron beam will penetrate the metal thin film of

two sheets out of a vacuum, and will be driven in into gas. The volume of the gas to excite reaches the aperture of 1m, and die length of 2m with large-sized equipment.

[0006] On the other hand, laser gas is filled up with the discharge excitation type equipment of the conventional technique shown in drawing 7 in the discharge tube, and gas is excited by inter-electrode discharge. In drawing 7 , cathode 21 and an anode plate 12 are installed in the both sides of the gas container 6, and laser gas 5 is filled among both. The die length of about several cm and an electrode of both width of face and spacing of an electrode is about 50-100cm. By connecting the source 11 of acceleration voltage to cathode 21, the high voltage (several 10kV) is impressed to inter-electrode, and medium gas is excited by inter-electrode glow discharge. In order to obtain stable glow discharge, it is necessary to generate uniformly the charge of amount sufficient at the time of discharge starting to a discharge field, therefore X-ray irradiation or UV irradiation performs preliminary ionization of laser gas 5.

[0007]

[Problem(s) to be Solved by the Invention] With conventional electron-beam-excitation-type gas laser equipment A vacuum and laser medium gas The thin film to separate () [<A HREF="/Tokujitu/tjitemdrw.ipdl?N0000=237&N0500=1E_N/;> <?>:7;?///&N0001=338&N0552=9&N0553=000008"] In the gas maintenance thin film 10 of TARGET="tjitemdrw"> drawing 6, electronic are recording and scattering loss were large, and this energy loss had restricted the effectiveness of the whole equipment greatly. There was a problem of the vacuum leakage by the thin film seal part which separates gas and a vacuum in long duration actuation of laser equipment to coincidence, the mechanical-strength fall of a thin film, the corrosion of the thin film by laser gas, and contamination of the laser gas accompanying it. Generally, since diameter[of macrostomia]-izing is easy for electron-beam-excitation-type equipment, it fits generating of high power laser light. However, since the gas maintenance thin film 10 was used, it was impossible to have generated high power laser light that it is efficient and continuously under the high repeat actuation covering long duration.

[0008] Moreover, in conventional electron-beam-excitation type equipment, generation of an electron beam was greatly restrained by the above-mentioned electron emission device. That is, in order that the amount of electron emission from a cathode surface might be dependent on the configuration and magnitude of a minute projection, and number density, when these geometric conditions were insufficient, generation of the cathode surface plasma by the emission electron had taken time amount. Therefore, compaction of the build up time of an electron beam current wave form was difficult (about 40 - 50ns). Moreover, since the impedance of the electron beam generating section was dependent on an electrode surface product and spacing, and applied voltage, the amount of electron beam currents was prescribed by these conditions, and a free expansion of electron beam emission area was difficult. Since the cathode surface plasma furthermore progressed in the direction of an anode plate with time amount, the substantial electrode spacing decreased with time amount, and a time reduction of an impedance was brought about. For this reason, it was difficult to keep constant electron beam acceleration voltage and a current value in electrical-potential-difference impression time amount.

[0009] Also in the equipment of a discharge excitation type, difficulty was in electron emission from the electrode. With the gas laser equipment of this method, high electric field needed to be impressed to inter-electrode [with which gas was filled up for the electron emission from cathode], therefore the glow discharge in the inside of gas became unstable, and there was a fault of being easy to shift to arc discharge. Although the equipment of a discharge excitation type was excellent in high repeat actuation, diameter[of macrostomia]-izing of the discharge tube, i.e., generation of a large area and high power laser light, was impossible for it because of such discharge instability.

[0010] Then, this invention solves this trouble, makes it possible to drive in an electron directly into gas from ferroelectric cathode, and aims at offering the gas excitation equipment in which high power, efficient, and quantity repeat actuation are possible.

[0011]

[Means for Solving the Problem] The component constituted from a ferroelectric or a ferroelectric, and an electrode is used for this invention as an electron beam generation source. However, the dimension of the ferroelectric in an electron beam generation source, a configuration, and the configuration approach of an electrode are not limited to one. Moreover, the device for the electronic drawer from a ferroelectric is not necessarily needed for the location separated from the ferroelectric.

[0012] As the one creation approach of the source of electron emission using a ferroelectric, an electron emission component is constituted by inserting a ferroelectric plate with two electrode plates (drawing 1 - drawing 5). Metal vacuum evaporationo **** thin enough which is extent which covers the electron emission side of a ferroelectric plate with the electrode of the shape of surface type, such as the shape of a slit, so that some ferroelectrics may be outside exposed, or an electron penetrates is covered and grounded with a metal thin film etc. (slit electrode 2 of drawing 1 -

drawing 5). A rear-face side covers the whole surface of a ferroelectric completely with a uniform electrode (reversal electrode 3 of drawing 1 - drawing 5), and the power source for impressing the below-mentioned high-voltage pulse is connected (reversal voltage source 8).

[0013] A straight polarity pulse is impressed to the reversal electrode 3 by the side of the introduction rear face, and an electron is accumulated in a slit-like electrode or a metal thin film by the side of a front face etc. (slit electrode 2). In the case of a slit-like electrode, an electron is accumulated also in the ferroelectric front face of the clearance between slits. Next, the electrical-potential-difference polarity of the reversal electrode 3 is quickly reversed to negative, and polarization in a dielectric is reversed. In the case of a slit-like electrode, by this rapid polarization reversal, the electron which was being accumulated in the ferroelectric front face of the clearance between slits is calculated outside electrostatic through the clearance between slits. Moreover, in the case of the electrode constituted from metal vacuum evaporationo film or a metal thin film, the electron accumulated in the thin film passes direct or a thin film from a thin film front face, and it is calculated outside electrostatic. Drive in the calculated electron into gas as it is, it is made to collide with a gas molecule, and gas is excited.

[0014] As long as conditions allow in the case of this electronic flipping ****, only a negative polarity pulse may be impressed to the reversal electrode 3 from the start, and the effectiveness same [without reversing an electrical potential difference on the way] may be produced. The electron emitted from the ferroelectric may be accelerated by external electric field if needed (drawing 2 , 3). Moreover, the orbit of an emission-electron beam, a cross-section configuration, or a dimension may be controlled by the location of arbitration (drawing 4 , 5).

[0015] Thus, where a ferroelectric and gas are contacted, it becomes possible to make an electron emit directly into gas from a ferroelectric. Consequently, the following matters or actuation is attained.

[0016] (1) Since the direct electron emission to the inside of gas becomes possible, remove the gas maintenance thin film 10 which was being used in electron-beam-excitation type gas laser equipment, and the gas excitation method which drives in an electron beam into direct gas, without minding a vacuum becomes possible. By adopting this method, various problems which originated in the gas maintenance thin film until now are solved.

(2) In electron-beam-excitation type equipment, generation of the cathode surface plasma becomes unnecessary in the case of the electron emission from cathode to the inside of a vacuum. Therefore, in conventional equipment, the build up time of an electron beam current can be shortened sharply.

(3) In electron-beam-excitation type equipment, the problem of the progress of the plasma in the direction of an anode plate from a cathode surface is solved. Therefore, in conventional equipment, time fluctuation of the acceleration voltage of an electron beam and a current value decreases.

(4) In an electron-beam-excitation type and discharge excitation type equipment, since the existing provisions for electron beam generation (an electrode surface product, an electrode spacing, field strength, etc.) are eased sharply, expansion of the emission-electron beam cross section becomes very easy.

(5) In discharge excitation type equipment, since the heavy current community for electron emission becomes unnecessary, an inter-electrode electrical potential difference can be reduced, and the stability of glow discharge improves.

(6) In discharge excitation type equipment, electron emission becomes very easy and preliminary ionization of indispensable gas becomes unnecessary with conventional equipment.

[0017]

[Embodiment of the Invention] The gas laser equipment which is made to emit an electron from the component hereafter constituted from a ferroelectric as shows this invention to drawing 1 - drawing 5 , generates an electron beam, devotes itself into gas, and excites gas is made into an example, and is explained to a detail.

[0018] Drawing 1 contacts a ferroelectric and gas and shows the 1st example of a configuration which is made to emit an electron into direct gas from a ferroelectric, and excites gas. Here, the example of a configuration which faces across both sides of the tabular ferroelectric 1 with the electrode of two sheets is shown. Although it is usable if there is about 1mm of thickness of a ferroelectric from several 100 microns, according to the purpose and operation, the thickness beyond it is sufficient. It covers and grounds with a slit-like electrode (slit electrode 2) so that some ferroelectrics may be exposed in respect of electron emission. The width of face (width of face of a ferroelectric exposure) of a slit is comparable as the thickness of a ferroelectric 1, or it is desirable to make it less than [it]. However, the width of face of a slit does not emit an electron in zero. Since the one thinner enough of the thickness of a slit electrode is advantageous to electron emission compared with the thickness of a ferroelectric, metal vacuum evaporationo or a metal mesh thin enough may constitute a slit electrode. Or a slit electrode etc. may not be used but the whole electron emission side may be covered with the metal vacuum evaporationo film or metal thin film of thinness which is extent which can penetrate electronic. On the other hand, it sets at the rear face of the opposite side, and is completely a wrap

(reversal electrode 3) with an electrode about the whole ferroelectric surface.
[0019] The reversal voltage source 8 is connected to the reversal electrode 3 on the back, and the square wave of amphipathy like illustration is impressed to a reversal electrode. Although the magnitude of applied voltage is decided by dielectric-breakdown reinforcement of a ferroelectric, it is several [about] kV per thickness of 1mm of a ferroelectric. For pulse width, although based on the purpose of use, straight polarity and negative polarity are several 10ns. They are extent or more than it.
[0020] When a straight polarity electrical potential difference is impressed to the introduction reversal electrode 3, a charge is accumulated in both sides of a ferroelectric 1 like charge of the usual capacitor. In the slit electrode 2 side used as an electron emission side, an electron is accumulated also in the ferroelectric front face of the part of the clearance between slits.
[0021] Next, if the polarity of the reversal electrode 3 is quickly reversed from forward to negative, polarization of the ferroelectric 1 interior will be reversed and negative polarization charge will be generated inside the ferroelectric near the slit electrode 2 side. The electron which was being accumulated in the ferroelectric front face by the side of a slit electrode as a result is calculated outside electrostatic through the clearance between slits. When the electrode by the side of an electron emission side is constituted by the metal vacuum evaporationo film or the metal thin film, an electron is calculated through direct or a thin film from those thin film front faces. The time amount by which an electron is calculated is equal to negative polarity pulse width about. The calculated electron is driven in into direct laser gas 5, and laser gas is excited by making it collide with a gas molecule. Consequently, the laser light 7 can be taken out towards illustration.
[0022] By following this example, the gas maintenance thin film which was being used in conventional electron-beam-excitation type equipment becomes unnecessary, and it becomes possible to drive in an electron beam into direct gas, without minding a vacuum. By adopting this method, various troubles resulting from a gas maintenance thin film are canceled, and the energy transfer efficiency of equipment is also improved sharply. Moreover, also in conventional discharge excitation type equipment, electron emission becomes very easy, the stability of discharge is acquired and diameter[of macrostomia]-izing and high power-ization of equipment are attained.
[0023] Drawing 2 makes an electron once emit into a vacuum from a ferroelectric, and shows the 2nd example of a configuration driven in into gas through a thin film next. The electron emission device from a ferroelectric is completely the same as the case where it illustrates to drawing 1 R> 1. That is, the reversal voltage source 8 is connected to the reversal electrode 3 on the back, a bipolar pulse like illustration is impressed to the reversal electrode 3, and an electron is calculated electrostatic from the surface slit electrode 2.
[0024] In this 2nd example of a configuration, the source 11 of acceleration voltage is connected to the both sides of the slit electrode 2 of the both sides of a ferroelectric 1, and the reversal electrode 3, and the negative high voltage (100kV of numbers [-]) is impressed. Therefore, the grounded gas maintenance thin film 10 (metal thin film) functions as an anode plate. It is accelerated in the vacuum acceleration section 9, and the electron emitted from the slit electrode side on the front face of a ferroelectric serves as the electron beam 4 of high energy, and is driven in into laser gas 5 through the gas maintenance thin film 10. Since a gas maintenance thin film is usually the thickness of several 10 microns, an electron beam penetrates a thin film and enters into laser gas. When the electron beam of high energy is required, and an electron is made to once emit into a vacuum like this example, it accelerates and it is devoted into gas through a thin film after that, it is advantageous in many cases.
[0025] This invention contributes to the property improvement of the electron beam generating section in conventional electron-beam-excitation type equipment greatly. In conventional equipment, there were the difficulty of the lateness of the standup of an electron beam current wave form, the electrical potential difference within (several 10ns - about 100ns of numbers) electron beam duration, fluctuation of a current value, and electron beam cross-section expansion and un-arranging [of **]. These all originated in the difficulty of the electron emission from cathode. That is, much minute projections (height, width of face, several 10 - 100 microns of numbers) were prepared in the cathode surface (electron emission side 20 of drawing 6 R> 6) installed into the vacuum, electric field were emphasized by the projection point (several more than MV/cm), and the electron was made to emit into a vacuum from the local high electric-field section in electron-beam-excitation type equipment (field emission). Therefore, in order that the amount of electron emission might be dependent on the area consistency of the form of a minute projection of a cathode surface, magnitude, and the number of projections etc., when the geometric condition of these cathode surfaces was inadequate, the good electron emission characteristic was not acquired. Moreover, the latency time produced [the plasma after electron emission from a minute projection] the cathode surface on the wrap occasion, and this made difficult compaction of the build up time of an electron beam wave (about 40 - 50ns). Furthermore, the impedance of the electron beam generating section (between cathode and an anode plate) decreased in time with progress in the

direction of an anode plate of the cathode surface plasma, and, as a result, the electron beam electrical potential difference and the current suited the inclination to fall in the second half of a pulse. It was what also depends the difficulty of electrode surface product expansion on these constraint.

[0026] In the 2nd example of a configuration shown in drawing 2 , it becomes unnecessary to make a cathode surface produce a heavy current community on the occasion of electron emission, and the electron emission to the inside of a vacuum becomes very easy. Moreover, since generation of the cathode surface plasma also becomes unnecessary, various constraint about the electron beam generation in equipment is mitigated sharply conventionally. That is, when using a gas maintenance thin film as usual in electron-beam-excitation type equipment, stabilization of compaction of the build up time of an electron beam current wave form which was difficult until now, an electron beam electrical potential difference, and a current value, expansion of an electrode surface product, etc. become easy, and it becomes possible to improve the property of equipment sharply. By following this 2nd example of a configuration, the design of the diameter of macrostomia and high power high performance electron-beam-excitation type equipment is attained further.

[0027] Drawing 3 makes an electron emit into direct gas, and shows the 3rd example of a configuration which accelerates an electron in gas. The electron emission device from a ferroelectric is completely the same as the case of the 1st and 2nd examples of a configuration. As shown in drawing 3 , the source of electron emission constituted from a ferroelectric 1 is made to counter with an anode plate 12, and it installs, and between both is filled with laser gas 5. The source 11 of acceleration voltage is connected to an anode plate 12, the forward electrical potential difference of several 10kV is impressed, and while accelerating the electron emitted from the ferroelectric 1 in laser gas 5, laser gas 5 is excited. The laser light 7 is taken out towards illustration.

[0028] This 3rd example of a configuration is equivalent to having improved conventional discharge excitation type gas laser equipment. In this example of a configuration, an advantageous point is that the need of making a cathode surface producing a heavy current community for electron emission is lost. for this reason, an inter-electrode electrical potential difference can be reduced in discharge excitation type equipment, and the stability of glow discharge is markedly alike and improves. Moreover, when electron emission becomes easy, the preliminary ionization device of indispensable gas can be removed with discharge excitation type equipment until now, and large simplification of equipment is attained. These results, it becomes possible to set up comparatively freely and the diameter of macrostomia and high power discharge excitation type gas laser equipment excellent in the discharge stability which was impossible until now also realize an electrode surface product and an electrode spacing.

[0029] Drawing 4 shows the 4th example of a configuration which controls an electron beam by electric field in the 1st example of a configuration. In drawing 4 , the electric-field generating electrode 13 is installed in the field of the gas container 6 top and the bottom, according to the electric-field generating voltage source 14, the high voltage is impressed and electric field 15 are produced in the direction of a vertical. The orbit of an electron beam 4, a cross-section configuration, and a dimension are controlled by this electric field 15. The number of the electric-field generating electrodes 13 is not limited to two. The direction of electric field 15 is not limited in the direction of a vertical, either. Moreover, you may use together with the electron beam control (drawing 5) by the below-mentioned field. This electron beam control approach may be applied not only to the 1st example of a configuration but to other examples of a configuration.

[0030] Drawing 5 shows the 5th example of a configuration which controls an electron beam by the field in the 1st example of a configuration. In drawing 5 , the field generating coil 18 is installed so that an electron beam 4 may be surrounded around the gas container 6, according to the excitation current source 17, a high current is passed and a field 16 is produced in parallel with an electron beam 4. The orbit of an electron beam 4, a cross-section configuration, and a dimension are controlled by this field 16. The field generating coil 18 is not limited to two. The direction of a field 16 is not limited in the direction of an electron beam 4, either. Moreover, you may use together with the electron beam control (drawing 4 R> 4) by the above-mentioned electric field. This electron beam control approach may be applied not only to the 1st example of a configuration but to other examples of a configuration.

[0031]

[Effect of the Invention] If this invention is applied to electron-beam-excitation type gas laser equipment, it will become possible to remove the gas maintenance thin film which was indispensable until now in equipment of the same kind, and the diameter gas laser equipment of macrostomia of a completely new gas excitation method will be realized. With the equipment of this new method, problems, such as breakage of are recording and scattering loss of the electron in a thin film, and a thin film, vacuum leakage, corrosion of a thin film, and contamination of gas, are solved at once. Consequently, efficient and quantity repeat actuation over the long duration of high power gas laser equipment are attained.

[0032] When applying this invention to the electron-beam-excitation type equipment as usual which uses a gas maintenance thin film, improvement in compaction of the build up time of an electron beam current, an electron beam electrical potential difference, and the stability of a current is attained, and expansion of an electrode surface product also becomes very easy. Much more high-performance-izing of electron-beam-excitation type equipment, and diameter [of macrostomia]-izing and high-power-izing are attained these results.
[0033] if this invention is applied to discharge excitation type gas laser equipment, since the heavy current community of the cathode surface which was required on the occasion of electron emission will become unnecessary and the reduction of inter-electrode electric field of it will be attained, the stability of glow discharge is markedly alike and improves. Moreover, since expansion of an electrode surface product and spacing becomes very easy, large increase of gas capacity is attained. Since it becomes still more unnecessary [the preliminary ionization device of gas], large simplification of equipment is also attained. Diameter[of macrostomia]-izing of discharge excitation type gas laser equipment which was difficult until now, and high power-ization are realized these results.
[0034] As mentioned above, the completely new high performance gas laser equipment with which the demerit of the conventional electron-beam-excitation type, a discharge excitation type, and both sides was compensated, and the advantage was doubled and in which high power, efficient, and high repeat actuation are possible is realized. This invention contributes to implementation of the future high power and efficient gas laser driver for nuclear fusion with which high repeat actuation is demanded or high-power-izing of the high repeat laser equipment already widely used in the industrial world, and diameter-ization of macrostomia greatly.

[Translation done.]

* NOTICES *

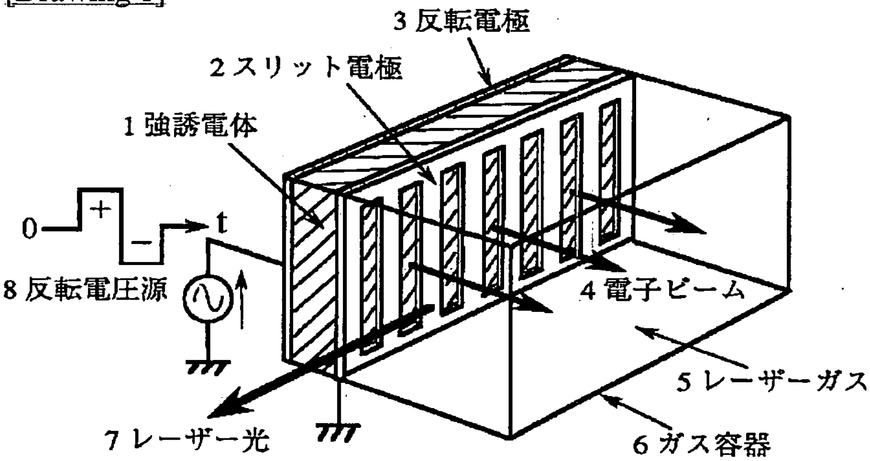
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The 1st example of a configuration of this invention is shown, and the example which is made to emit an electron directly into gas from a ferroelectric, and excites gas is shown.
[Drawing 2] The 2nd example of a configuration of this invention is shown, an electron is made to once emit into a vacuum from a ferroelectric, it accelerates, and the example which is made to pass a thin film after that and is driven in into gas is shown.
[Drawing 3] The 3rd example of a configuration of this invention is shown, and the example which accelerates in gas the electron made to emit directly into gas from a ferroelectric is shown.
[Drawing 4] The 4th example of a configuration of this invention is shown, and the example which controls the orbit of an electron beam, a cross-section configuration, and a dimension by electric field in the 1st example of a configuration is shown.
[Drawing 5] The 5th example of a configuration of this invention is shown, and the example which controls the orbit of an electron beam, a cross-section configuration, and a dimension by the field in the 1st example of a configuration is shown.
[Drawing 6] Conventional electron-beam-excitation type gas laser equipment is shown.
[Drawing 7] Conventional discharge excitation type gas laser equipment is shown.
[Description of Notations]
1 Ferroelectric
2 Slit Electrode
3 Reversal Electrode
4 Electron Beam
5 Laser Gas
6 Gas Container
7 Laser Light
8 Reversal Voltage Source
9 Vacuum Acceleration Section
10 Gas Maintenance Thin Film
11 Source of Acceleration Voltage
12 Anode Plate
13 Electric-Field Generating Electrode
14 Electric-Field Generating Voltage Source
15 Electric Field
16 Field
17 Excitation Current Source
18 Field Generating Coil
19 Electric Insulating Plate
20 Electron Emission Side
21 Cathode

[Translation done.]

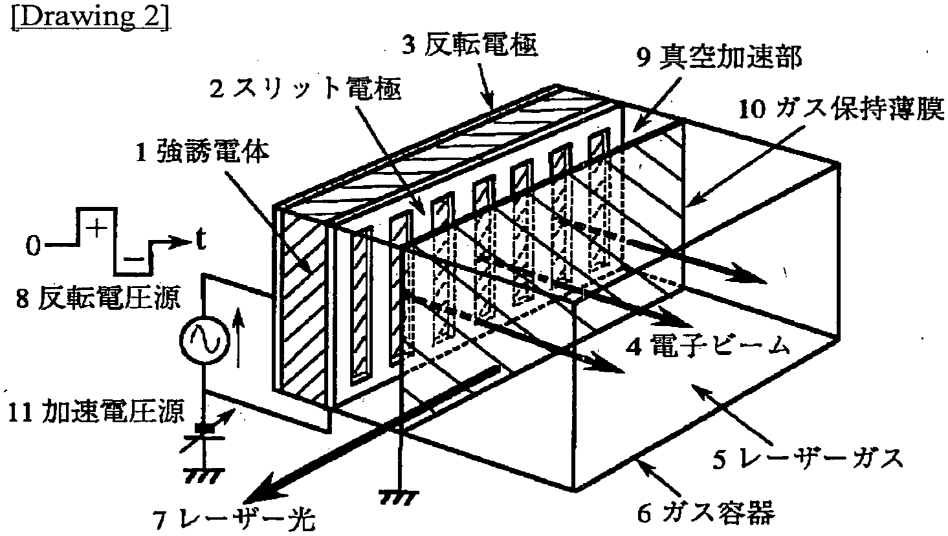
DRAWINGS

[Drawing 1]



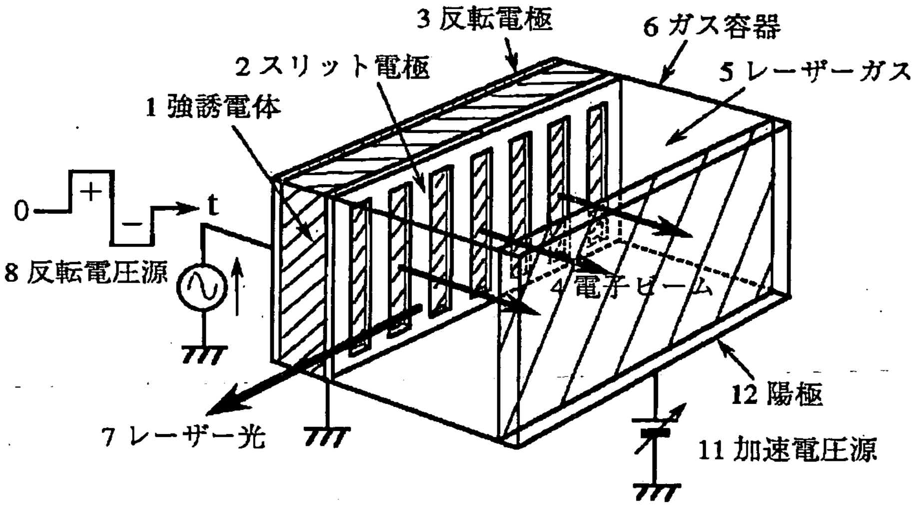
強誘電体からの放出電子によるガスの励起

[Drawing 2]



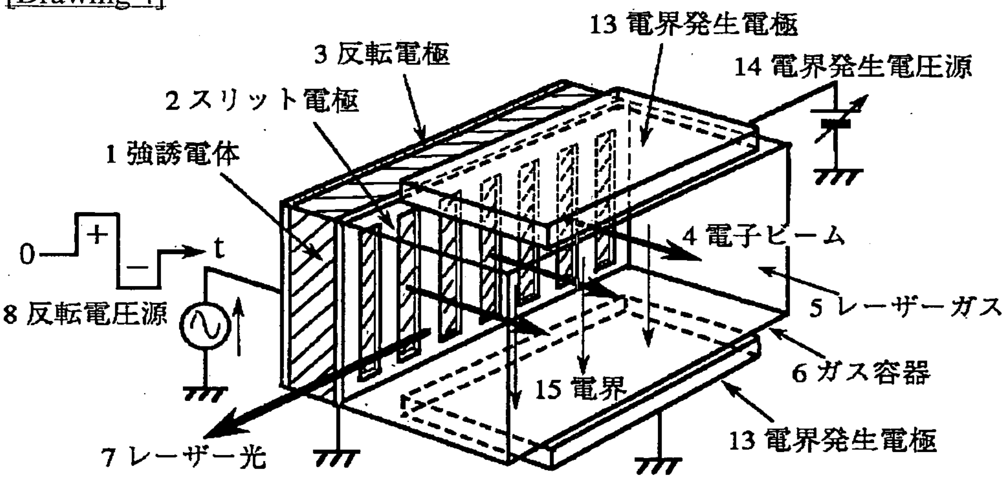
真空中での放出電子の加速

[Drawing 3]



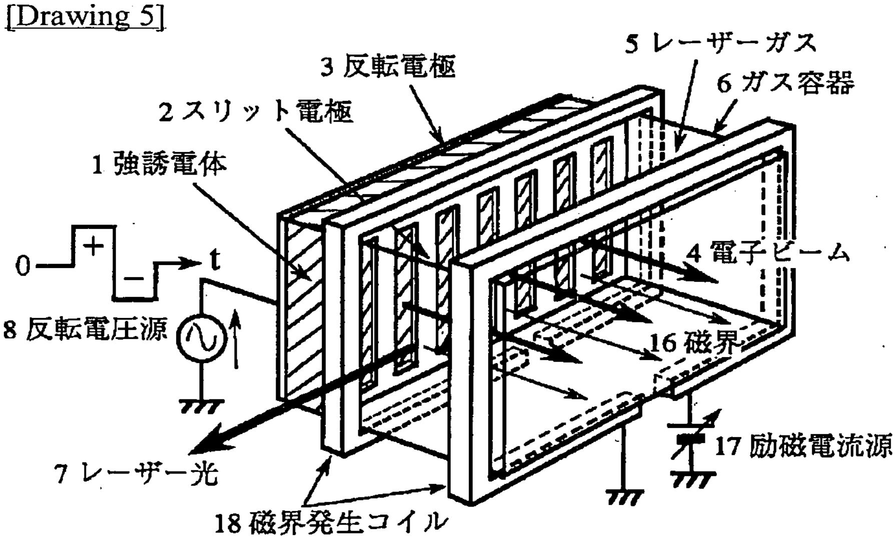
ガス中での放出電子の加速

[Drawing 4]



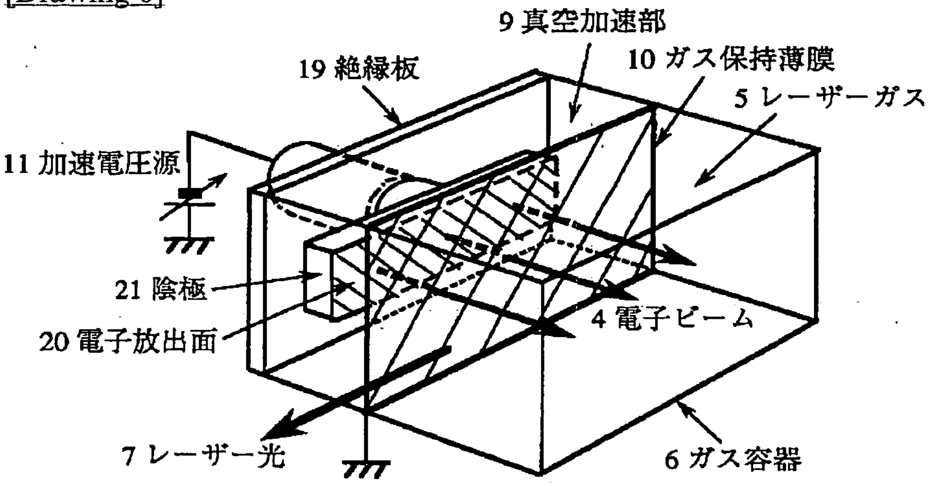
電界による電子ビーム制御

[Drawing 5]



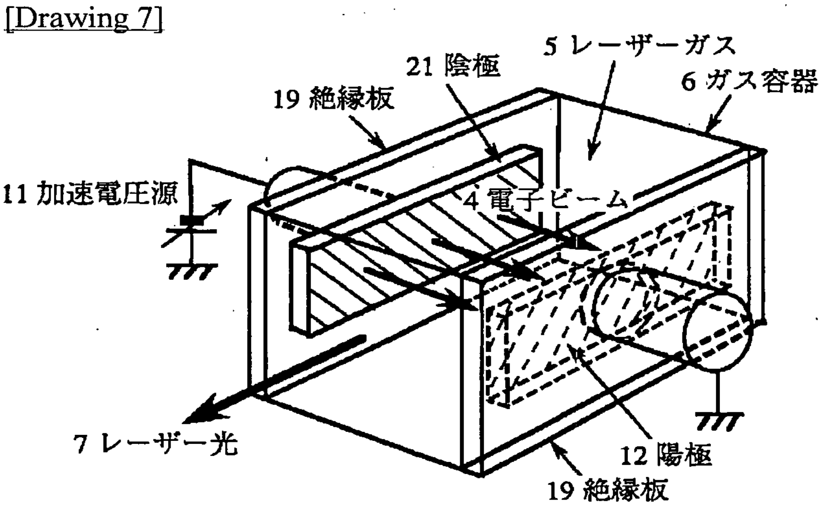
磁界による電子ビーム制御

[Drawing 6]



従来技術（電子ビーム励起式ガスレーザー装置）

[Drawing 7]



従来技術（放電励起式ガスレーザー装置）

[Translation done.]

WRITTEN AMENDMENT

-- [a procedure revision]
[Filing Date] July 19, Heisei 11 (1999. 7.19)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim
[Method of Amendment] Modification
[Proposed Amendment]
[Claim(s)]
[Claim 1] When this electron beam generation source impresses a pulse voltage to a ferroelectric in the gas excitation equipment which pours in into gas the electron made to emit from an electron beam generation source, and excites it, it is gas excitation equipment characterized by being the thing to which an electron is made to emit.
[Claim 2] Said electron beam generation source is gas excitation equipment according to claim 1 characterized by having inserted the ferroelectric plate with two electrode plates, and impressing a pulse voltage to these two electrode plates.
[Claim 3] One side of said two electrode plates is gas excitation equipment according to claim 2 characterize by constitute from the metal vacuum evaporationo film thin enough or metal thin film which constitutes , and is make to emit an electron from the this exposed field , or an electron penetrates , and which is extent so that some ferroelectrics may be outside exposed , and make an electron emit from the metal thin film .
[Claim 4] Gas excitation equipment according to claim 3 characterized by having impressed the amphipathy square wave pulse voltage reversed from straight polarity to negative polarity to the electrode by the side of the rear face of said two electrode plates, and grounding the electrode plate by the side of an electron emission side.
[Claim 5] Gas excitation equipment according to claim 3 characterized by preparing the anode plate which connected the source of acceleration voltage to it while impressing the amphipathy square wave pulse voltage reversed from straight polarity to negative polarity to the electrode by the side of the rear face of said two electrode plates and grounding the electrode plate by the side of an electron emission side to it.
[Claim 6] Gas excitation equipment according to claim 1 to 5 characterized by pulling out an electron from a ferroelectric where said ferroelectric and gas are contacted, and pouring in an electron directly into gas from a ferroelectric.
[Claim 7] Gas excitation equipment according to claim 1 to 3 characterized by making an electron once emit into a vacuum from said ferroelectric, and pouring in an electron into gas through a diaphragm etc. after that.
[Claim 8] Gas excitation equipment according to claim 7 which connects the source of acceleration voltage to a surface electrode, and makes a two-electrodes plate negative quantity potential, and is characterized by having grounded said diaphragm and making it function as an anode plate while impressing an amphipathy square wave pulse voltage which a rear-face electrode reverses from straight polarity to the surface electrode by the side of electron emission between said two electrode plates at negative polarity.
[Claim 9] Gas excitation equipment according to claim 1 to 8 characterized by having prepared the electrode of the pair for controlling the orbit of said electron beam made to emit, a cross-section configuration, and a dimension by electric field, and impressing an electrical potential difference to this inter-electrode ones.
[Claim 10] Gas excitation equipment according to claim 1 to 9 characterized by having had the field generating coil for controlling the orbit of said electron beam made to emit, a cross-section configuration, and a dimension by the field, and passing a current in this coil.

-- [a procedure revision]
[Filing Date] January 31, Heisei 12 (2000. 1.31)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim
[Method of Amendment] Modification
[Proposed Amendment]
[Claim(s)]
[Claim 1] When this electron beam generation source impresses a pulse voltage to a ferroelectric in the gas excitation equipment which pours in the electron made to emit from an electron beam generation source into laser gas, and excites it, it is gas excitation equipment characterized by being the thing to which an electron is made to emit.
[Claim 2] Said electron beam generation source is gas excitation equipment according to claim 1 characterized by having inserted the ferroelectric plate with two electrode plates, and impressing a pulse voltage to these two electrode plates.
[Claim 3] One side of said two electrode plates is gas excitation equipment according to claim 2 characterize by constitute from the metal vacuum evaporationo film thin enough or metal thin film which constitutes , and is make to emit an electron from the this exposed field , or an electron penetrates , and which is extent so that some ferroelectrics may be outside exposed , and make an electron emit from the metal thin film .
[Claim 4] Gas excitation equipment according to claim 3 characterized by having impressed the amphipathy square wave pulse voltage reversed from straight polarity to negative polarity to the electrode by the side of the rear face of said two electrode plates, and grounding the electrode plate by the side of an electron emission side.
[Claim 5] Gas excitation equipment according to claim 3 characterized by preparing the anode plate which connected the source of acceleration voltage to it while impressing the amphipathy square wave pulse voltage reversed from straight polarity to negative polarity to the electrode by the side of the rear face of said two electrode plates and grounding the electrode plate by the side of an electron emission side to it.
[Claim 6] Gas excitation equipment according to claim 1 to 5 characterized by pulling out an electron from a ferroelectric where said ferroelectric and gas are contacted, and pouring in an electron directly into gas from a ferroelectric.
[Claim 7] Gas excitation equipment according to claim 1 to 3 characterized by making an electron once emit into a vacuum from said ferroelectric, and pouring in an electron into gas through a gas maintenance thin film after that.
[Claim 8] Gas excitation equipment according to claim 7 which connects the source of acceleration voltage to a surface electrode, and makes a two-electrodes plate negative quantity potential, and is characterized by having grounded said gas maintenance thin film and making it function as an anode plate while impressing an amphipathy square wave pulse voltage which a rear-face electrode reverses from straight polarity to the surface electrode by the side of electron emission between said two electrode plates at negative polarity.
[Claim 9] Gas excitation equipment according to claim 1 to 8 characterized by having prepared the electrode of the pair for controlling the orbit of said electron beam made to emit, a cross-section configuration, and a dimension by electric field, and impressing an electrical potential difference to this inter-electrode ones.
[Claim 10] Gas excitation equipment according to claim 1 to 9 characterized by having had the field generating coil for controlling the orbit of said electron beam made to emit, a cross-section configuration, and a dimension by the field, and passing a current in this coil.

[Translation done.]